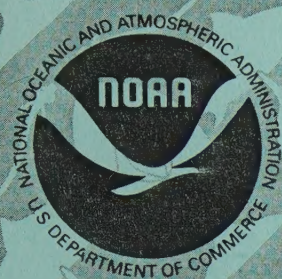


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NUMBERS OF DOLPHIN CHASED, CAPTURED
AND INJURED INCIDENTAL TO FISHING BY
THE U.S. PURSE-SEINE FISHERY FOR
TROPICAL TUNA IN THE EASTERN PACIFIC OCEAN
1977-1983

By

W. W. PARKS

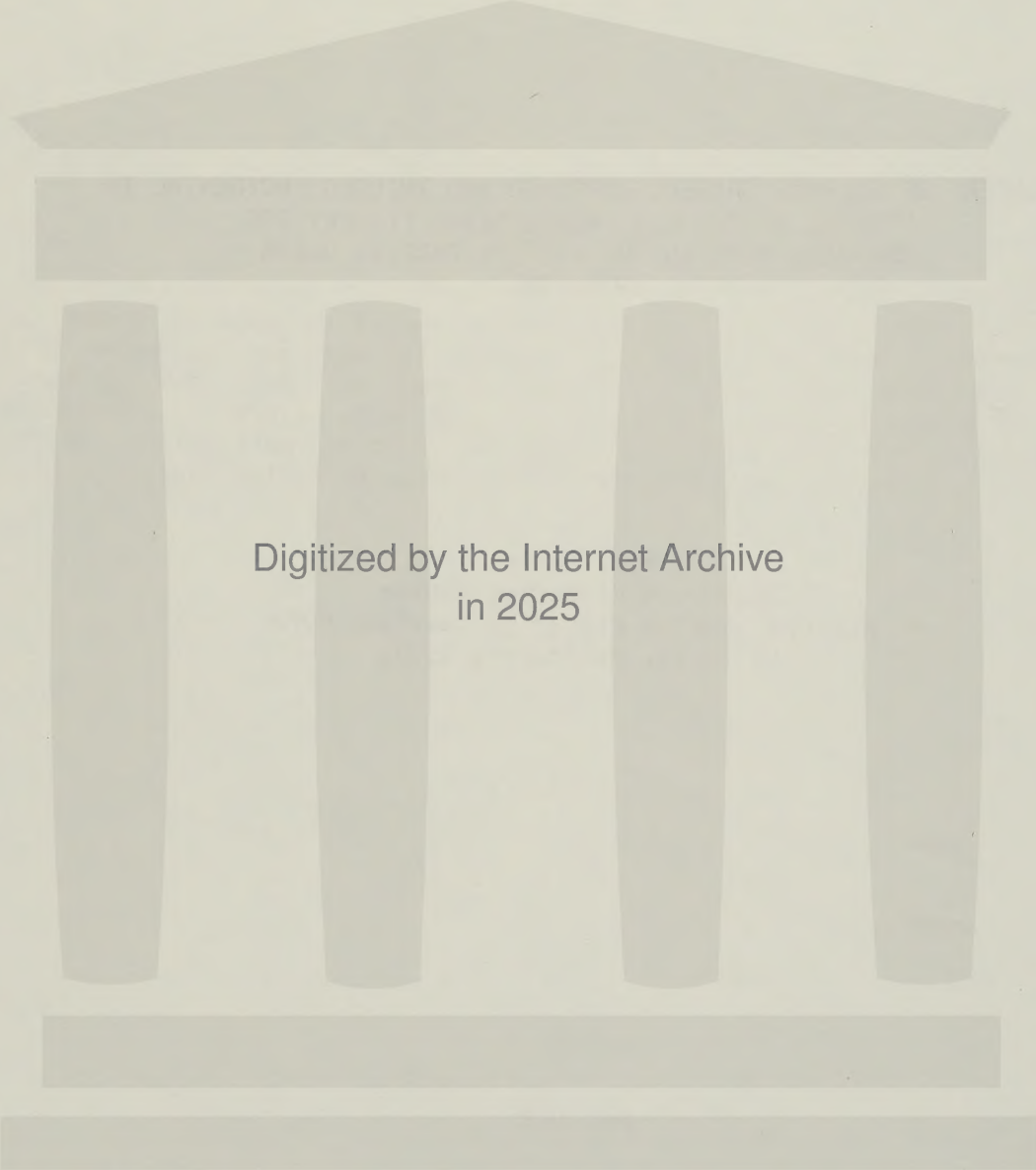
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1977-1983

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May 1985



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NUMBERS OF DOLPHIN CHASED, CAPTURED AND INJURED INCIDENTAL TO
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ABSTRACT. The U.S. purse-seine fishery for tropical tunas in the eastern Pacific Ocean uses schools of dolphins to locate schools of tuna with which they are associated. In the process of catching tunas, associated dolphins are chased, captured and occasionally injured. Under the Marine Mammal Protection Act, NMFS has the task to estimate the "take" of dolphins by the U.S. fishery. Take is defined as any impact on dolphins by man. Estimates of numbers of dolphins chased, captured and injured by species group for the years 1977-1983 were made. Estimates were made using data of numbers-chased, captured and injured-per-set and total sets. Estimates of numbers injured were made using two estimates of injury, one including only those dolphins observed to be injured and alive, the other adding to this dolphins observed to be in uncertain condition. Estimates of numbers injured were added to estimates (from other sources) of numbers killed to produce worst-case-estimates of total mortality.

The estimated numbers of dolphin chased, captured, and injured declined steadily between 1977 and 1983. Adding estimates of numbers injured to estimates of numbers killed increased annual estimates of mortality by up to 16 percent.

INTRODUCTION

Schools of several species of dolphin in the eastern tropical Pacific Ocean (ETP), principally spotted dolphin (Stenella attenuata) and spinner dolphin (S. longirostris), travel in the company of yellowfin tuna (Thunnus albacares), the dolphins swimming at the surface above the tuna in an association of unknown cause (Perrin 1969). The purse-seine fishery for

tropical tuna in the ETP uses the presence of schools of dolphin to locate associated schools of tuna. Nets are set around both schools, the dolphin released and the tuna kept. Occasionally, in the process some of the captured dolphins are killed or injured.

The Marine Mammal Protection Act of 1972 (MMPA) sets guidelines for the take of dolphins incidental to purse-seine fishing for tuna by U.S. fishermen. The act assigns the task of monitoring the condition of dolphin stocks to the National Marine Fisheries Service (NMFS). This task includes determining the abundance of dolphin associated with the fishery as well as the level of take (Wahlen 1984).

MMPA defines the act of taking marine mammals as to "... harass, hunt, capture or kill or attempt to harass, hunt, capture, or kill any marine mammal." To monitor the take by the U.S. fishery, NMFS calculates mortality and injury incidental to fishing and estimates numbers of dolphins chased and captured (Smith 1979).

Direct mortality is estimated using data of observed sample kill-per-set collected by observers aboard U.S. vessels and estimates of total sets. Estimates are made for individual strata and summed for estimates of annual mortality. Estimates of direct mortality have been made for the period 1973-1983 (Smith, 1979; Wahlen, 1984; Hammand and Tsai, 1984; and Hammond and Hall, In Press).

Three estimates of numbers of dolphins injured can be made using data of numbers injured-per-set and total sets. Data collected for observed set beginning in 1975 include numbers of dolphins (1) seriously injured, but released alive, (2) observed injured but of uncertain status (dead or alive) on release, and (3) number in uncertain condition (injured or uninjured) and of uncertain status on release. Observer instructions define dolphins as seriously injured those that are "... bleeding, have obviously broken bones or have passed through the power block." Estimates of numbers of dolphin injured have been made for the period 1975-1978 (Smith 1979).

Numbers of dolphins chased and captured can also be estimated using data of sample chase, or capture-per-set and estimates of total sets. Observer records include estimated numbers chased defined as those affected by all activity in a set up to the time the seine skiff is released to encircle tuna and dolphins. Estimated numbers captured are defined as those observed in the net after the net has been pursed.

In this report I describe research to estimate numbers of dolphin injured by the U.S. Fleet during the period 1977-1983. Participants of the Status of Porpoise Workshop in 1979 chose as the best estimate of total mortality "... the sum of the estimated number directly killed and the estimated number seriously injured ... (Smith 1979)." Following this example, I also calculated estimates of total mortality of dolphin incidental to fishing as the sum of my estimates of numbers injured and estimated numbers directly killed. To complete the picture I estimated numbers of dolphin chased and captured by the U.S. fleet.

METHODS AND DATA

Data of estimated numbers of dolphin chased, captured and injured during purse seine sets were recorded by scientific observers aboard selected U.S. tuna purse-seiners fishing in the ETP. Two agencies, NMFS and the Inter-American Tropical Tuna Commission (IATTC), conducted the observer programs. NMFS data cover the entire period 1977-1983; IATTC data cover only recent years, since 1979.

Estimates of the total number of fishing trips made by U.S. vessels by year and area were made using extractions of data from the IATTC logbook data base (Table 1). Independent estimates of the total number of sets by year were obtained from various sources that used the technique of Punsley (1983). Numbers of trips and sets were distributed over areas according to proportions in extracted IATTC logbook data (Table 1). On the average 51% of all trips and 43% of all sets by U.S. vessels during the 1977-1983 were sampled (Table 1).

I used two estimates for numbers of dolphins injured. The first was numbers of dolphins observed to be injured but alive on release. The second is the sum of the first and estimates of (1) numbers of dolphin observed to be injured but of uncertain status (dead or alive) and (2) numbers observed of uncertain condition (injured or uninjured) and of uncertain status. Since at least some of those dolphins in categories (1) and (2) are alive and injured, my first estimate of injury is low. Since it is unlikely that all of (1) and (2) are alive and injured, my second estimate is high.

I stratified the data by the three areas of Wahlen (1984): (1) inside the IATTC's Commission Yellowfin Regulatory Area (CYRA) and north of the equator, (2) outside the CYRA and north of the equator and (3) south of the equator (Figure 1, from Wahlen 1984). To keep results consistent with Wahlen's stratification I followed his scheme for years 1977 and after of not stratifying for season or vessel capacity.

I estimated numbers of dolphin chased, captured or injured using stratified ratio estimator techniques of Lo et al. (1982). Estimates for a year, area stratum were computed as the product of total sets on dolphin (Table 1) and the per-set ratio for numbers chased, captured or injured (Tables 2 - 5).

I estimated the variance of the estimates of numbers of dolphin chased, captured or injured during a year as the sum of estimates of variance for area strata. I estimated variances for individual areas as the square of the product of total dolphin sets and the standard error of the per set ratios (Tables 2 - 5).

I estimated numbers, and variances of estimates of numbers, chased, captured and injured by year and species in the same way as above, using data for individual species alone (Tables 6 - 7).

I calculated worst-case estimates of total mortality by year and species in two ways (Table 8). For the first, Kill 2, I estimated mortality as the sum of the estimated numbers directly killed, Kill 1, and the estimated numbers injured (definition 1). The second, Kill 3, I calculated as the sum of Kill 1 and estimated numbers injured (definition 2).

RESULTS

Estimated numbers of dolphin chased by U.S. purse-seiners declined steadily from 9,500,000 in 1977 to 1,700,000 in 1983 (Table 9). Estimated numbers of dolphin captured similarly declined from 4,700,000 to 1,200,000 over the same period (Table 9).

Estimated numbers of dolphin injured (definition 1) incidental to the U.S. fishery declined from 803 in 1977 to 56 in 1983 (Table 9). Except for an increase in 1978, the decline in estimated numbers injured using definition 2 was similar, from 1700 in 1977 to 180 in 1983 (Table 9).

Estimates of number injured were added to existing estimates of numbers killed to produce worst-case estimates of mortality. Adding injuries using definition 1 increased estimates of numbers killed annually by a maximum of 3.6% (Table 10). Adding injuries using definition 2 increased estimates of numbers killed by up to 15.7% (Table 10).

DISCUSSION

Estimates of numbers of dolphin injured have been previously estimated for 1975 through 1978 (Smith 1979). Estimates presented here for 1977 and 1978 are very close to these (Table 11). Typically, estimates using injury definition 1 are less than corresponding estimates of Smith (1979), while those using injury definition 2 are greater than reported by Smith (1979). The precision of estimates in the two series is comparable. As mentioned above, estimates made under the two definitions are clearly low and high estimates. There is no evidence suggesting that either is better and together they constitute a series of interval estimates.

Following Wahlen (1984), differences between estimates presented here and those in Smith (1979) are probably due to differences in stratification used in the two analyses. I used Wahlen's stratification, by area only, while analyses reported by Smith stratified by vessel capacity and catch as well as by area. Wahlen (1984) presents a complete discussion of the differences and their likely effects.

Both injury series show steady declines for the period 1977-1983 (Table 11). These declines are less pronounced than the decline in estimated annual injuries for the period 1975-1978 in Smith (1979), (Table 11). Declines are repeated in the series of injuries per set (Table 13). For injury definition 1, the injury rate declined from 0.11 dolphins injured per set in 1977 to 0.02 in 1983. The decline in injury rate is more pronounced for injury definition 2, from 0.024 in 1977 to 0.06 in 1983. The linear regression of injury rate on time is significant (five

percent level) for injury definition 1 and not significant for definition 2. This suggests that, at least for the more conservatively-defined injury, the U.S. fleet in recent years has improved those skills needed to avoid injuring captured dolphins.

Both injury series also show numbers injured in 1978 and 1981 that are larger than expected by the general decline over the period 1977-1983. Injury rates for these two years are also greater than expected by the general trend, especially for injury definition 2. The causes of these unexpected high rates are unknown. They may be due to some external factor such as unusually severe fishing conditions in these two years.

Following Smith (1979), worst-case estimates of kill of dolphins by the U.S. fleet assume the unlikely, that all injured animals eventually die. For the more conservative view of numbers injured, estimates are only slightly (3.6% maximum) greater than direct kills. Even for the clear overestimated definition 2, estimates are at most only 16% greater than direct kills.

Worst-case estimates of mortality are made using injuries calculated using Wahlen's (1984) stratification scheme by area, and species. While this is the same as the stratification used to estimate direct kill for 1977 and 1978 (Whalen 1984), it is not the same as the stratification used to estimate direct kill in later years, by species only (Hammond and Tsai, 1983; Hammond 1984; Hammond and Hall, 1984). While estimates of injury and kill are not strictly compatible for the later years, the effect of difference is probably not great and the use of one stratification is adequate for the purposes of making worst-case estimates of mortality.

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Table 1. Numbers of sampled trips and sets and estimated total number of trips and sets on porpoise by area by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983.

Year	Area	<u>Sampled</u>		<u>Total</u>	
		Trips	Sets	Trips	Sets
1977	Inside North	97	2796	190	5851
	Outside North	48	543	78	1136
	<u>South</u>	<u>16</u>	<u>73</u>	<u>37</u>	<u>252</u>
	Total	161	3412	305	7239
1978	Inside North	106	1162	212	2888
	Outside North	35	545	60	1164
	<u>South</u>	<u>18</u>	<u>83</u>	<u>27</u>	<u>162</u>
	Total	159	1790	299	4214 ²
1979	Inside North	103	2287	194	4607
	Outside North	24	452	51	1168
	<u>South</u>	<u>22</u>	<u>274</u>	<u>35</u>	<u>422</u>
	Total	149	3013	280	6197 ³
1980	Inside North	103	1645	184	3669
	Outside North	37	542	74	1339
	<u>South</u>	<u>16</u>	<u>122</u>	<u>26</u>	<u>251</u>
	Total	156	2309	284	5259 ³
1981	Inside North	87	1545	176	3706
	Outside North	32	670	66	1623
	<u>South</u>	<u>18</u>	<u>118</u>	<u>31</u>	<u>306</u>
	Total	137	2333	273	5635 ³
1982	Inside North	82	1357	162	3144
	Outside North	30	433	60	1017
	<u>South</u>	<u>26</u>	<u>233</u>	<u>39</u>	<u>407</u>
	Total	138	2023	261	4568 ⁴
1983	Inside North	37	448	95	1649
	Outside North	18	333	40	757
	<u>South</u>	<u>20</u>	<u>199</u>	<u>39</u>	<u>447</u>
	Total	75	980	174	2853 ⁵

¹Areas: Inside and Outside refer to the IATTC's yellowfin Regulatory area (CYRA); North and South refer to the equator.

²Peterson, 1983.

³Hammond and Tsai, 1983.

⁴Hammond, 1984.

⁵Hammond and Hall, 1984.

Table 2. Sample statistics for numbers of dolphin chased by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983.¹

Year	Area ²		Mean		Ch/S	SE(Ch/S)
			Ch/T	S/T		
1977	Inside	North	37,765.77	28.82	1,310.19	62.74
	Outside	North	14,954.56	11.31	1,321.95	530.03
		South	6,444.50	4.56	1,412.49	5,472.81
1978	Inside	North	12,621.66	10.96	1,151.37	260.35
	Outside	North	18,457.17	15.57	1,185.32	563.22
		South	6,411.11	4.61	1,390.36	4,086.91
1979	Inside	North	17,048.60	22.20	767.82	98.60
	Outside	North	13,809.17	18.83	733.23	606.73
		South	11,247.45	12.45	903.08	1,062.38
1980	Inside	North	13,557.03	15.97	848.86	191.34
	Outside	North	13,511.51	14.65	922.37	688.70
		South	5,936.31	7.63	778.53	2,344.00
1981	Inside	North	11,555.85	17.76	650.72	176.87
	Outside	North	18,953.41	20.94	905.24	606.81
		South	6,234.06	6.56	950.96	3,395.92
1982	Inside	North	13,794.38	16.55	833.56	279.58
	Outside	North	11,038.00	14.43	764.76	846.05
		South	8,165.81	8.96	911.21	1,549.76
1983	Inside	North	6,302.65	12.11	520.53	625.44
	Outside	North	11,046.17	18.50	597.09	934.23
		South	8,204.50	9.95	824.57	2,042.86

¹Statistics: Ch/T = number chased per trip; S/T = number of sets per trip; Ch/S = Number chases per set; SE (CH/S) = Standard error of the estimate of Ch/S.

²Areas: See Table 1.

Table 3. Sample statistics for numbers of dolphin captured by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983.¹

Year	Area ²		Mean			SE(Ch/S)
			C/T	S/T	C/S	
1977	Inside	North	16,990.72	28.82	589.45	32.17
	Outside	North	9,506.42	11.31	840.35	337.44
		South	4,629.75	4.56	1,014.74	3,931.30
1978	Inside	North	5,424.34	10.96	494.84	112.94
	Outside	North	11,104.80	15.57	713.15	339.31
		South	5,118.56	4.61	1,110.05	3,263.60
1979	Inside	North	8,238.31	22.20	371.03	48.50
	Outside	North	8,889.54	18.83	472.01	390.18
		South	9,569.27	12.45	768.34	903.36
1980	Inside	North	6,738.52	15.97	421.93	94.58
	Outside	North	8,867.57	14.65	605.35	451.77
		South	4,400.88	7.63	577.16	1,738.60
1981	Inside	North	5,288.63	17.76	297.81	81.05
	Outside	North	12,643.53	20.94	603.87	405.13
		South	5,603.72	6.56	854.81	3,052.81
1982	Inside	North	7,404.99	16.55	447.46	151.23
	Outside	North	7,554.03	14.43	523.37	578.80
		South	6,840.46	8.96	763.31	1,298.36
1983	Inside	North	3,227.35	12.11	266.54	320.76
	Outside	North	9,164.56	18.50	495.38	775.53
		South	7,468.15	9.95	750.57	1,859.14

¹Statistics: C/T = numbers captured per trip; S/T = number of sets per trip; C/S = numbers captured per set; SE(C/S) = standard error of the estimate of C/S.

²Area: See Table 1.

Table 4. Sample statistics for numbers of dolphin injured (definition 1) by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983.^{1,2}

Year	Area ²		Mean		I1/S	SE(I1/S)
			I1/T	S/T		
1977	Inside	North	3.29	28.82	0.11	0.02
	Outside	North	1.21	11.31	0.11	0.04
		South	0.25	4.56	0.05	0.22
1978	Inside	North	1.86	10.96	0.17	0.06
	Outside	North	1.80	15.57	0.12	0.06
		South	- ⁴	-	-	-
1979	Inside	North	1.19	22.20	0.05	0.01
	Outside	North	0.83	18.83	0.04	0.04
		South	0.77	12.45	0.06	0.07
1980	Inside	North	0.48	15.97	0.03	0.01
	Outside	North	0.62	14.65	0.04	0.03
		South	4.38	7.63	0.57	1.76
1981	Inside	North	1.06	17.76	0.06	0.02
	Outside	North	2.78	20.94	0.13	0.12
		South	0.06	6.56	0.01	0.03
1982	Inside	North	1.01	16.55	0.06	0.03
	Outside	North	0.77	14.43	0.05	0.06
		South	0.58	8.96	0.06	0.11
1983	Inside	North	0.22	12.11	0.02	0.02
	Outside	North	-	-	-	-
		South	0.60	9.95	0.06	0.15

¹Injured (definition 1) = noted as injured, alive on set logs.

²Statistics: I1/T = number injured per trip; S/T = number of sets per trip; I1/T = number injured per trip; SE(I1/T) = Standard error of I1/T.

³Area: See Table 1.

⁴None injured in sample data.

Table 5. Sample statistics for numbers of dolphin injured (definition 2) by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983.^{1,2}

Year	Area ²	Mean		I2/S	SE(I2/S)
		I2/T	S/T		
1977	Inside North	6.74	28.82	0.23	0.03
	Outside North	2.83	11.31	0.25	0.10
	South	1.56	4.56	0.34	1.33
1978	Inside North	7.75	10.96	0.71	0.30
	Outside North	3.09	15.57	0.20	0.10
	South	0.44	4.61	0.10	0.28
1979	Inside North	2.96	22.20	0.13	0.03
	Outside North	1.75	18.83	0.09	0.08
	South	1.50	12.45	0.12	0.15
1980	Inside North	1.01	15.97	0.06	0.02
	Outside North	0.84	14.65	0.06	0.05
	South	4.94	7.63	0.65	1.98
1981	Inside North	2.10	17.76	0.12	0.04
	Outside North	9.56	20.94	0.46	0.42
	South	0.17	6.56	0.03	0.09
1982	Inside North	2.70	16.55	0.16	0.08
	Outside North	1.30	14.43	0.09	0.10
	South	1.19	8.96	0.13	0.23
1983	Inside North	1.05	12.11	0.09	0.11
	Outside North	- ⁴	-	-	-
	South	0.90	9.95	0.09	0.23

¹Injured (definition 2) = noted as injured, uncertain status; unknown injury, uncertain status on set logs.

²Statistics: I2/T = number injured per trip; S/T = number of sets per trip; I2/T = number injured per trip; SE(I2/T) = Standard error of I2/T.

³Area: See Table 1.

⁴None injured in sample data.

Table 6. Estimates of numbers of dolphin chased and captured by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983. Estimates are by species, stocks or groups of species. Coefficients of variation of estimates are also listed.

Year	Group	Chased		Captured	
		Number	CV	Number	CV
1977	Spotted	7,399,233	0.18	4,102,223	0.22
	Eastern Spinner	430,881	0.09	133,606	0.11
	White Belly Spinner	505,093	0.44	308,980	0.53
	Unidentified Spinner	169,678	0.18	13,986	0.27
	Total Spinner	1,105,653	0.22	456,572	0.36
	Common	819,872	0.28	95,674	0.31
	Striped	5,680	0.97	1,419	1.17
	Other	9,783	0.53	3,109	2.63
	Unidentified	183,362	0.23	218	2.82
	Total	9,523,582	0.16	4,659,216	0.23
1978	Spotted	3,937,928	0.26	2,140,771	0.31
	Eastern Spinner	179,289	0.26	61,723	0.25
	White Belly Spinner	320,159	0.27	185,352	0.32
	Unidentified Spinner	109,087	0.24	6,669	0.37
	Total Spinner	608,535	0.22	253,745	0.26
	Common	180,706	0.32	40,694	0.40
	Striped	10,664	0.58	3,257	0.47
	Other	732	0.37	305	0.39
	Unidentified	191,556	0.27	255	1.18
	Total	4,930,121	0.24	2,439,027	0.30
1979	Spotted	3,550,206	0.22	2,182,090	0.25
	Eastern Spinner	284,534	0.17	109,223	0.19
	White Belly Spinner	166,584	0.60	162,704	0.51
	Unidentified Spinner	127,698	0.25	16,979	0.45
	Total Spinner	578,816	0.24	288,906	0.34
	Common	550,467	0.21	129,017	0.20
	Striped	5,361	0.29	3,831	0.38
	Other	502	0.27	371	0.30
	Unidentified	109,775	0.26	810	0.78
	Total	4,774,863	0.20	2,584,883	0.25

Table 6. Continued

Year	Group	Chased		Captured	
		Number	CV	Number	CV
1980	Spotted	3,566,372	0.27	2,154,332	0.33
	Eastern Spinner	164,164	0.24	79,675	0.28
	White Belly Spinner	208,212	0.50	175,106	0.54
	Unidentified Spinner	151,845	0.28	17,982	0.35
	Total Spinner	524,222	0.29	272,763	0.39
	Common	266,021	0.41	88,866	0.47
	Striped	7,061	0.54	5,686	0.53
	Other	284	0.38	176	0.52
	Unidentified	180,975	0.61	3,960	0.86
	Total	4,544,935	0.29	2,503,481	0.33
1981	Spotted	3,028,461	0.38	1,923,814	0.47
	Eastern Spinner	296,363	0.29	73,584	0.27
	White Belly Spinner	204,522	0.84	200,554	1.11
	Unidentified Spinner	113,485	0.36	9,458	0.75
	Total Spinner	638,355	0.38	283,596	0.81
	Common	234,108	0.55	58,808	0.60
	Striped	3,478	1.19	726	2.20
	Other	2,152	0.45	384	0.35
	Unidentified	265,199	0.46	5,567	0.71
	Total	4,171,753	0.38	2,345,323	0.50
1982	Spotted	2,917,502	0.38	1,920,977	0.41
	Eastern Spinner	224,949	0.36	131,518	0.41
	White Belly Spinner	184,450	0.60	180,594	0.58
	Unidentified Spinner	149,055	0.38	50,386	0.74
	Total Spinner	558,454	0.35	298,699	0.47
	Common	65,930	0.38	32,834	0.40
	Striped	9,396	1.09	2,578	0.69
	Other	2,068	0.54	430	0.42
	Unidentified	242,951	0.41	2,087	1.52
	Total	3,769,328	0.37	2,249,768	0.41
1983	Spotted	1,148,922	0.94	948,384	1.02
	Eastern Spinner	128,882	1.09	61,660	1.01
	White Belly Spinner	121,502	1.24	123,421	1.22
	Unidentified Spinner	99,198	1.24	12,339	1.18
	Total Spinner	349,582	0.91	197,420	0.96
	Common	44,941	1.28	3,644	1.24
	Striped	296	1.73	529	1.68
	Other	239	1.09	63	1.27
	Unidentified	171,763	1.03	0	0
	Total	1,678,937	0.92	1,150,040	1.00

Table 7. Estimates of numbers of dolphin injured, by two definitions of injury, by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983¹. Estimates are by stocks, species or groups of species. Coefficients of variation of estimates are also listed.

1977	Spotted	437	0.14	989	0.15
	Eastern Spinner	57	0.24	88	0.24
	White Belly Spinner	133	0.22	234	0.54
	Unidentified Spinner	2	0.69	2	0.69
	Total Spinner	192	0.17	324	0.39
	Common	126	0.32	259	0.33
	Striped	10	3.96	10	3.96
	Other	17	0.71	17	0.71
	Unidentified	21	0.37	140	0.61
	Total	803	0.15	1,739	0.22
1978	Spotted	375	0.26	1,671	0.47
	Eastern Spinner	32	0.45	87	0.36
	White Belly Spinner	143	0.51	315	0.51
	Unidentified Spinner	15	0.64	22	0.67
	Total Spinner	190	0.42	425	0.41
	Common	15	0.45	27	0.56
	Striped	20	0.73	32	0.68
	Other	2	0.74	5	0.54
	Unidentified	22	0.59	126	0.40
	Total	624	0.28	2,287	0.38
1979	Spotted	180	0.27	362	0.25
	Eastern Spinner	12	0.34	58	0.31
	White Belly Spinner	40	0.71	52	0.69
	Unidentified Spinner	6	0.53	9	0.49
	Total Spinner	58	0.50	119	0.36
	Common	64	0.28	227	0.40
	Striped	0	0	2	0.70
	Other	22	0.48	22	0.48
	Unidentified	2	1.31	42	0.48
	Total	326	0.24	774	0.22

¹For definitions of injury, see Tables 4 and 5.

Table 7. Continued

Year	Group	Injured ¹		Injured ²	
		Number	CV	Number	CV
1980	Spotted	272	1.50	400	1.10
	Eastern Spinner	4	0.69	18	0.44
	White Belly Spinner	27	1.47	34	1.36
	Unidentified Spinner	0	-	7	0.70
	Total Spinner	31	1.26	58	0.81
	Common	0	-	0	-
	Striped	0	-	0	-
	Other	2	0.70	2	0.70
	Unidentified	5	1.01	11	1.75
	Total	310	1.44	471	1.07
1981	Spotted	243	0.41	380	0.36
	Eastern Spinner	5	0.56	17	0.39
	White Belly Spinner	78	0.79	97	0.80
	Unidentified Spinner	0	-	0	-
	Total Spinner	82	0.75	114	0.70
	Common	62	0.54	156	0.52
	Striped	0	-	0	-
	Other	0	-	0	-
	Unidentified	51	0.96	538	0.96
	Total	439	0.47	1,188	0.60
1982	Spotted	227	0.42	557	0.46
	Eastern Spinner	23	0.48	32	0.46
	White Belly Spinner	15	0.91	36	0.72
	Unidentified Spinner	0	-	0	-
	Total Spinner	38	0.47	68	0.46
	Common	5	0.59	7	0.52
	Striped	0	-	0	-
	Other	2	0.79	5	0.60
	Unidentified	0	-	0	-
	Total	273	0.42	658	0.43
1983	Spotted	25	1.83	132	1.19
	Eastern Spinner	22	1.44	40	1.44
	White Belly Spinner	9	2.54	9	2.54
	Unidentified Spinner	0	-	0	-
	Total Spinner	31	1.26	49	1.26
	Common	0	-	0	-
	Striped	0	-	0	-
	Other	0	-	0	-
	Unidentified	0	-	2	2.58
	Total	56	1.40	184	1.16

Table 8. Estimates of numbers of dolphin killed incidental to fishing by the U.S purse-seine fishery for tropical tuna in the ETP, 1977-1983. Estimates are for three definitions of mortality.¹

Year	Group	Kill1	Kill2	Kill3
1977 ²	Spotted	14,000	14,400	15,000
	Eastern Spinner	1,300	1,400	1,400
	White Belly Spinner	3,600	3,700	3,800
	Unidentified Spinner	100	100	100
	Total Spinner	5,000	5,200	5,300
	Common	3,000	3,100	3,300
	Striped	200	200	200
	Other and Unidentified	600	600	800
	Total	22,800	23,500	24,600
1978 ²	Spotted	9,000	9,400	10,700
	Eastern Spinner	700	700	800
	White Belly Spinner	2,300	2,400	2,600
	Unidentified Spinner	0	0	0
	Total Spinner	3,000	3,100	3,400
	Common	1,500	1,500	1,500
	Striped	100	100	100
	Other and Unidentified	400	400	500
	Total	14,000	14,500	16,200
1979 ³	Spotted	8,100	8,300	8,500
	Eastern Spinner	1,100	1,100	1,200
	White Belly Spinner	1,900	1,900	2,000
	Unidentified Spinner	200	200	200
	Total Spinner	3,200	3,200	3,400
	Common	4,400	4,500	4,600
	Striped	200	200	200
	Other and Unidentified	500	500	600
	Total	16,400	16,700	17,300

¹Kill1 = numbers killed using numbers recorded as killed on set logs;

Kill2 = Kill1 + numbers injured (Definition 1);

Kill3 = Kill1 + numbers injured (Definition 2).

²Wahlen 1984.

³Hammond & Tsai 1983 (Kill/set estimator).

⁴Hammond 1984 (Kill/set estimator).

⁵Hammond and Hall 1984 (Kill/set estimator).

Table 8. Continued

Year	Group	K1111	K1112	K1113
1980 ³	Spotted	11,400	11,700	11,800
	Eastern Spinner	700	700	700
	White Belly Spinner	3,900	3,900	3,900
	Unidentified Spinner	100	100	100
	Total Spinner	4,700	4,700	4,700
	Common	400	400	400
	Striped	100	100	100
	Other and Unidentified	300	300	300
	Total	16,900	17,200	17,300
1981 ³	Spotted	11,400	11,600	11,800
	Eastern Spinner	1,600	1,600	1,600
	White Belly Spinner	3,300	3,400	3,400
	Unidentified Spinner	100	100	100
	Total Spinner	5,000	5,100	5,100
	Common	1,300	1,400	1,500
	Striped	100	100	100
	Other and Unidentified	200	300	700
	Total	18,000	18,500	19,200
1982 ⁴	Spotted	15,700	15,900	16,300
	Eastern Spinner	1,900	1,900	1,900
	White Belly Spinner	4,000	4,000	4,000
	Unidentified Spinner	100	100	100
	Total Spinner	6,000	6,000	6,000
	Common	400	400	400
	Striped	500	500	500
	Other and Unidentified	600	600	600
	Total	23,200	23,400	23,800
1983 ⁵	Spotted	3,700	3,700	3,800
	Eastern Spinner	600	600	600
	White Belly Spinner	3,800	3,800	3,800
	Unidentified Spinner	0	0	0
	Total Spinner	4,400	4,400	
	Common	200	200	200
	Striped	0	0	0
	Other and Unidentified	100	100	100
	Total	8,400	8,400	8,400

Table 9. Estimates of numbers of dolphin chased, captured and injured, by two definitions of injury, by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983¹. Coefficients of variation of estimates are also listed.

Year	Chased		Captured		Injured1		Injured2	
	Number	CV	Number	CV	Number	CV	Number	CV
1977	9,500,000	0.16	4,700,000	0.23	803	0.15	1,739	0.22
1978	4,900,000	0.24	2,400,000	0.30	624	0.28	2,287	0.38
1979	4,800,000	0.20	2,600,000	0.25	326	0.24	774	0.22
1980	4,500,000	0.29	2,500,000	0.33	310	1.44	471	1.07
1981	4,200,000	0.38	2,300,000	0.50	439	0.47	1,183	0.60
1982	3,800,000	0.37	2,200,000	0.41	273	0.42	658	0.43
1983	1,700,000	0.92	1,200,000	1.00	56	1.40	184	1.16

¹For definitions of injury see Tables 4 and 5.

Table 10. Estimates of numbers of dolphin killed incidental to fishing by the U.S. purse-seine fishery for tropical tuna in the ETP, 1977-1983. Estimates are for three definitions of mortality.¹

Year	K1111 ²	K1112	K1113
1977	22,800	23,500	24,600
1978	14,000	14,500	16,200
1979	16,400	16,700	17,300
1980	16,900	17,200	17,300
1981	18,000	18,500	19,200
1982	23,200	23,400	23,800
1983	8,400	8,400	8,400

¹For definitions of mortality see Table 8.

²For sources of estimates k1111 see Table 8.

Table 11. Estimated numbers of dolphin injured incidental to fishing by the U.S. purse-seine fishery for tropical tuna in the ETP in 1977 and 1978. Estimates are from Smith (1979) and the present analysis.¹ Coefficients of variation are listed in parentheses.

Stock	77			78		
	Smith 1979	Inj 1	Inj 2	Smith 1979	Inj 1	Inj 2
Spotted	777	437 (0.14)	989 (0.15)	523	375 (0.26)	1,671 (0.47)
Eastern Spinner	123	57 (0.24)	88 (0.24)	87	32 (0.45)	87 (0.47)
White Belly Spinner	223	133 (0.22)	234 (0.54)	196	143 (0.51)	315 (0.51)
Common	288	126 (0.32)	259 (0.33)	39	15 (0.45)	27 (0.56)
Total	1,407 (0.27)	803 (0.15)	1,739 (0.22)	841 (0.15)	624 (0.28)	2,287 (0.38)

¹For definitions of injury see Tables 4 and 5.

Table 12. Estimated number of dolphins injured incidental to fishing by the U.S. purse-seine fishery for tropical tuna in the ETP, 1975-1983. Estimates are from Smith (1979) and this analysis.¹

Year	Injured 1	Injured 2	Injured (SOPS 79)
1975	-2	-	9,690
1976	-	-	4,522
1977	803	1,739	1,407
1978	624	2,287	841
1979	326	774	-
1980	310	471	-
1981	439	1,183	-
1982	273	658	-
1983	56	184	-

¹For definitions of injury see Tables 4 and 5.

²Symbols: - = not estimated.

Table 13. Rates injury-per-set made on dolphin in the U.S. purse-seine fishery for tropical tuna, 1977-1982. Rates are for two definitions of injury.¹

Year	I1/Set	I2/Set
1977	0.11	0.24
1978	0.15	0.54
1979	0.05	0.12
1980	0.06	0.09
1981	0.08	0.21
1982	0.06	0.14
1983	0.02	0.06

¹For definitions of injury see Tables 4 and 5.

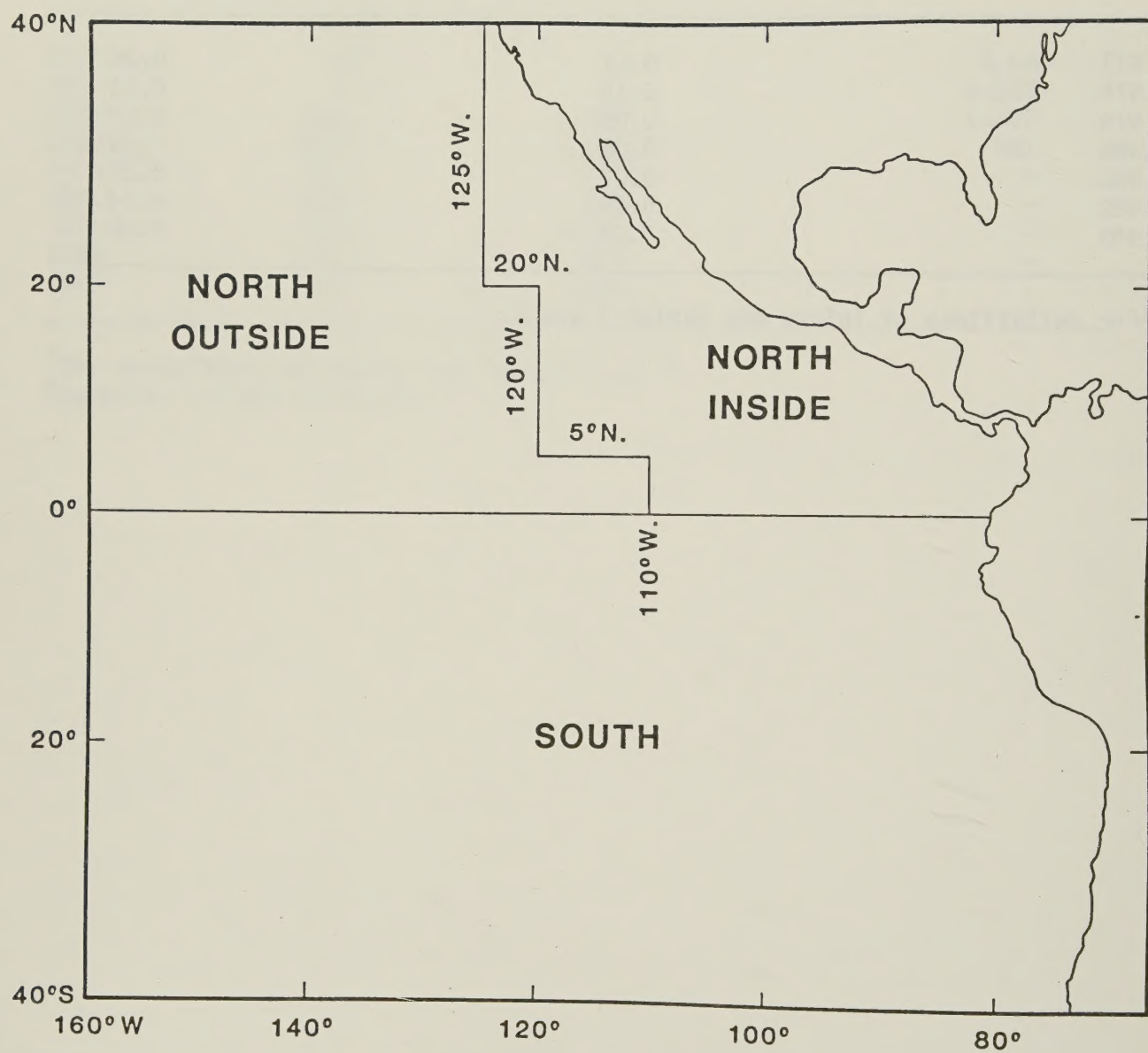


Figure 1. Areas used to stratify data (Figure 1 of Wahlen 1984).

